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Effects of Thinning Eastern Redcedar



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▲▲▲▲▲▲▲ ABSTRACT ▲▲▲▲▲▲▲

The impact of thinning on diameter, basal area, heartwood width and sapwood width was studied in 40-year-old pure stands of eastern reccedar (*Juniperus virginiana* L.) at a site near Branson, Missouri. Results 40 years after thinning indicated that mortality was high in unthinned plots, and negligible in the thinned plots. Mean tree diameter, basal area growth rate and heartwood width were higher in thinned than in unthinned plots 40 years after thinning. In contrast, no significant difference in sapwood width was detected between thinned and unthinned treatments. A strong linear relationship

between heartwood width and diameter was observed ($R^2 = 0.94$), indicating that the amount of heartwood was directly related to the size of the tree. A weaker relationship was obtained between diameter and sapwood width ($R^2 = 0.52$). Thus, in addition to increasing growth, thinning increased the heartwood width of eastern redcedar. Thinning is recommended as a sound management practice for eastern redcedar.

Key Words: Eastern redcedar, thinning, growth, heartwood formation

Eastern redcedar (*Juniperus virginiana* L.) is the most common coniferous species growing on a variety of sites throughout the eastern half of the United States (Lawson 1990, Figure 1). In Missouri, eastern redcedar is found in all counties, and is common in the central and southern regions of the state (Moser et al. 2007).

Redcedar grows under a wide range of climatic and soil conditions and can be found on almost any site and in conjunction with almost any plant community (Lawson 1990). It thrives on thin limestone soils and will successfully invade abused, overgrazed sites, abandoned pastures, and limestone rock exposures. It is found mostly on ridge tops and frequently on dry exposed sites. Like most tree species, eastern redcedar grows best on deep, moist, well-drained alluvial sites. On these better sites, hardwood competition is so severe that it rarely becomes dominant. Redcedar is classified as a slow grower, probably because it can persist on extremely poor sites, however, it can grow rapidly on better sites. State-wide forest inventory statistics show that the volume of redcedar growing stock doubled over a 14-year period from 250 million feet³ in 1989 to 500 million in 2003. The number of redcedar trees increased from 365 million to 600 million that same period (Moser et al. 2007). This large expansion of eastern redcedar in Missouri is due to land conversions, overgrazing, and fire suppression (Moser et al. 2007). If current agricultural trends and policies continue, the rate of expansion is likely to continue into the future. Many landowners have a negative view of eastern redcedar,

perceiving it as an invasive weed species, often chained, bulldozed and burned. As the resource has spread over time, its utilization and value in an array of products has become more widely recognized. Thus, expansion of eastern redcedar is increasingly being viewed as a growing economic opportunity for forest industries. The economic uses of eastern redcedar could compensate for the cost of removing trees on certain sites and eliminate disposal problems.

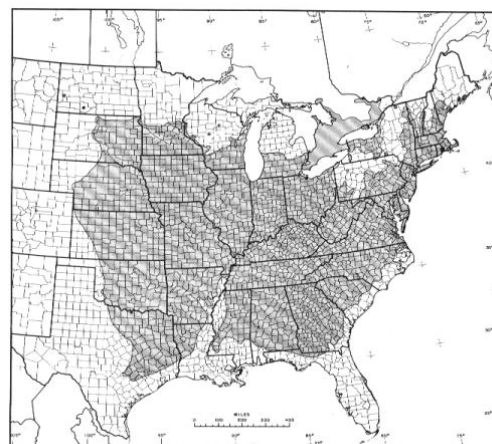


Figure 1. Natural range of eastern redcedar (Lawson 1990).

The significance of eastern redcedar is economic and environmental. Commercially, eastern redcedar wood is highly valued because of its beauty, durability, and workability. Primary products include posts, cants and lumber. Eastern redcedar makes excellent posts because of the durability of the heartwood. Eastern redcedar heartwood is prized for its pleasant fragrance and insect-repellant properties and is frequently used to line closets, wardrobes or cedar chests for inhibiting insects, such as moths and their larvae. Because of its beauty and durability it is used for many novelty items, flooring,

furniture and bird houses. It is used for mulching because of its appealing color, aroma, durability and insect deterrence properties. As wood utilization by-products, shavings are widely used for large and small animal pet bedding to minimize odor and repel fleas. Sawdust is currently being used to form composite water-resistant decks for houses. Cedarwood oil is extracted from trees as a fragrance base for soaps and cosmetics. From an environmental point of view, eastern redcedar makes excellent windbreaks and shelterbelts because of the dense, compact, long-lived foliage and low branches. Also, many species of birds and other animals feed on eastern redcedar fruit, and the dense foliage provides year round cover for many species of wildlife (Thompson and Fritzell 1988).

An increased understanding of impact of thinning eastern redcedar is important because thinning can improve not only growth and value of desired trees, but can increase herbaceous growth, and thereby improve wildlife habitat. Furthermore, thinning can reduce fire risk, because dense stands are also highly susceptible to fire and can increase the danger of wildfires (Moser et al. 2007).

Although there is a wealth of information about thinning conifers, particularly southern pines, in the United

States (Moehring et al. 1980), there is little research or experience with regard to thinning eastern redcedar. It is well known that density affects diameter growth, and thinning which releases trees from competition promotes diameter growth. Generally, thinning affects merchantable yield by distributing volume growth on fewer, larger trees (Smith 1962). Existing information on eastern redcedar from Arkansas indicates that growth and yield are affected by density (Ferguson et al. 1968). Over a 10-year period in northern Arkansas, completely released stands averaged higher growth in diameter, basal area and volume than stands where only crown competition was removed (Ferguson et al. 1968).

The goal of this study was to determine effects of thinning on diameter growth and heartwood formation. A recent market survey by University of Missouri Agroforestry Center indicated that the demand for good quality cedar will increase, and in the future the landowners should focus on producing good quality red cedar material (Gold, Godsey and Cernusca 2003). These conclusions underscore the importance of providing scientific information for improving both the quantity and quality of eastern redcedar.



Forty-year old pure eastern redcedar stands near Branson, Missouri, were thinned in 1968. Four, one-fifth acre plots were established, two in stands averaging 3.6 inches diameter (south plots) and two in stands averaging 5.8 inches diameter (north plots). One of the south plots was thinned from a basal area of about 80 to 42 feet² per acre, and one of the north plots was thinned from 66 to 54 feet² per acre. Thinning was carried out in winter of 1968-69. Measurements were taken before and after thinning in 1968, and in 1974, 1980, 1987 and 2007, thereafter referred to as 0, 5, 10, 20 and 40 years after thinning. These measurements were taken from the inner one-tenth acre of each plot. In 1987 and 2007 a core was taken at breast height from bark to pith on a radius facing plot center with an increment borer. The location of boring was moved slightly above or below

breast height to avoid branches or defects. Increment cores were checked in the field to ensure that the pith could be identified. The width of heartwood and sapwood were measured. The 2007 measurements were not available for the north stands because they were harvested prior to 2007.

Analyses were carried out for diameter, basal area, heartwood width and sapwood width for each age separately using “t” test. The PROC TTest procedure in SAS (SAS Institute 1985) was used to evaluate mean differences by treatments and PROC REG procedure in SAS (SAS Institute 1985) was used to test relationship between diameter and heartwood width, and diameter and sapwood width. Difference among treatments were considered significant if $P < 0.1$ to increase statistical power.



Residual stand conditions

Prior to thinning, the plots averaged 930 trees/ac for the south unthinned plot; 780 trees/ac for the south thinned plot; 310 trees/ac in the north unthinned plot and 400 trees/ac in the north thinned plot (Table 1). Diameter varied between treatments prior to thinning: 3.58 in. for unthinned south stand; 3.95 in. for thinned south stand; 5.76 in. for unthinned north stand and 5.92 in. for thinned north stand. Thus, south stands were more overstocked than the north stands, and had less diameter growth.

Approximately 48 percent of the basal area and 64% of the trees were cut from the south stand, and 39% of the basal area and 63% of the trees were cut in the north stand during thinning. Because thinning removed the smaller, less vigorous trees, the mean diameter in the thinned stands was higher immediately after thinning than before thinning. Mean diameter in the thinned south plot increased from 3.95 in. to 5.08 in. and in the thinned north plot from 5.92 in. to 7.97 in.

Table 1. Number of trees per acre, by treatment, before and after thinning in 40-year-old redcedar stands.

Location	Treatment	Before thinning (Yr 0)	After thinning (Yr 0)	Yr 5	Yr 10	Yr 20	Yr 40
South	Unthinned	930	930	780	690	600	480
	Thinned	780	280	310	300	290	280
North	Unthinned	310	310	230	220	210	-
	Thinned	400	150	150	150	150	-

Stand development following thinning

Stand development during the 40-year period was characterized by high mortality in the unthinned stands. The trees in the unthinned south stand steadily declined from 930 to 480 over the 40-year period. This reduction is equivalent to 48% mortality, and mortality is likely to continue in the future. In contrast, mortality in the south thinned stand was negligible. There was a mortality of 32% over the 20-year period in the unthinned north stand.

Mortality in the unthinned stands occurred primarily in the smaller, less vigorous trees and may have provided partial release from competition for adjacent surviving trees. On the other

hand, thinning removed large numbers of these types of trees in one operation rather than gradual over time. Removal of anticipated mortality through thinning provided much greater relief from competition to the residual trees than the gradual process of natural mortality could provide to surviving trees in the unthinned plots. Thus, thinning increased the rate of stand development in redcedar. The thinning at age 40 probably occurred too late. The high mortality observed in unthinned stands as early as five years after the study began indicates that the stands should have been thinned much earlier to avoid stress and mortality. Our results differ

from other early studies that reported that redcedar stands do not thin themselves naturally (Williamson 1957). For example, in 1903 an acre of land in Arkansas was planted with 1,225 seedlings and 44 years later 1,027 of these trees still survived with only 3% of the trees being overtopped (Arend 1947). In general, mortality is a reflection of stand quality with high mortality indicating poor stand quality. In our study the unthinned stands were of poor quality.

Thinning treatments increased the rate of basal area growth. Twenty years after thinning, basal area increased by 33% in the unthinned south plot, 95% in the thinned south plot, 24% in the unthinned

north plot and 63% in the thinned north plot. Forty years after thinning, basal area in the south stand increased by 75% in the unthinned stand and 155% in the thinned stand. In our study basal area growth rate was a better criterion to judge effects of thinning than individual tree growth rate.

In terms of total basal area, the unthinned plots in the south maintained the largest values at all ages. In the north plots the unthinned stand had less basal area than the thinned stand 10 years and more after thinning (Table 2). Although mortality in the unthinned plots of both the south and north stands was high, there was no serious loss in basal area.

Table 2. Stand basal area (ft^2/ac), by treatment, before and after thinning in 40-year-old redcedar stands.

Location	Treatment	Before thinning (Yr 0)	After thinning (Yr 0)	Yr 5	Yr 10	Yr 20	Yr 40
South	Unthinned	83	83	94	105	110	145
	Thinned	80	42	55	71	82	107
North	Unthinned	66	66	64	75	82	-
	Thinned	88	54	63	78	88	-

Diameter growth

Although there are no differences in diameter growth rates between thinned and unthinned stands after thinning, mean tree diameter of thinned stands was higher than that of unthinned stands (Table 3). Thinned stands had 27-29% greater individual-tree diameter than unthinned stands 20 years after thinning. The effect of thinning persisted through the 40-year period in the south stand with the thinned stands having 15% higher individual-tree diameter than

unthinned stands. The increase in diameter observed in the thinned stands was largely due to thinning at the beginning of the experiment and also growth of residual trees. Similarly, increase in diameter observed in the unthinned stands was due to mortality of small trees in addition to actual diameter growth of surviving trees. The mean diameter in unthinned plots is expected to be smaller than those in thinned plots because unthinned plots contained smaller intermediate and suppressed

trees. On the other hand, diameter in unthinned stands was also somewhat inflated by death of small trees. These confounding influences on diameter growth may mask important differences among treatments in individual-tree diameter growth. The inability of the trees in thinned plots to have a higher growth rate than those in the unthinned plots was at least partially due to the

relatively poor site and age of the stands. Also, the relatively long period of intense competition prior to thinning may have affected response of the south stands. However, the primary benefit of thinning was that it concentrated all the growth on the most desirable trees unlike in the unthinned plots where growth was spread across desired and undesired trees.

Table 3. Mean stand diameter (in.), by treatment, before and after thinning in 40-year-old redcedar stands. Standard deviations are given in parenthesis. Significance level is indicated.

Location	Treatment	Before thinning (Yr 0)	After thinning (Yr 0)	Yr 5	Yr 10	Yr 20	Yr 40
South	Unthinned	3.52 (1.91)	3.52 (1.91)	4.28 (1.98)	4.88 (2.06)	5.38 (2.22)	7.06 (2.37)
	Thinned	3.95 (1.81)	5.08 (1.40)	5.45 (1.81)	6.34 (1.90)	6.97 (1.82)	8.11 (2.06)
	P value	0.152	<0.001	0.005	0.001	0.001	0.054
North	Unthinned	5.61 (2.58)	5.61 (2.58)	6.67 (2.59)	7.55 (2.18)	8.04 (2.64)	-
	Thinned	5.92 (2.36)	7.97 (1.51)	8.65 (1.18)	9.60 (2.87)	10.25 (1.70)	-
	P value	0.597	0.002	0.012	0.008	0.008	

Heartwood and sapwood formation

Thinning significantly increased heartwood and sapwood widths over a 20-year period in the north stand (Table 4). Thinning did not affect either the heartwood or sapwood widths in the south stands at 20 years, but did increase heartwood width at 40 years. It appears that heartwood formation in the south stand responded much slower to thinning, possibly due to severe competition prior to thinning. The north thinned plot, aside from larger diameter trees, was a more open stand, and

formation of heartwood responded better to thinning.

When heartwood width was plotted against diameter a strong linear relationship was evident ($P < 0.001$, Figure 1). In other words, heartwood formation is a function of diameter growth as indicated by the polynomial equation:

$$Y = 0.34X - 0.13, R^2 = 0.94$$

where: Y is the predicted width of the heartwood in inches. X is tree diameter outside bark in inches. In contrast, the

linear relationship between sapwood width and diameter was relatively weak ($Y = 0.10X + 0.5$, $R^2 = 0.52$, Figure 2).

Additionally, heartwood width was higher and sapwood slightly lower 40 years after thinning than 20 years after thinning. Thus, tree size and age are the key factors influencing heartwood formation in eastern redcedar. Sapwood

width tends to decrease with age. The strong relationship between diameter and heartwood width serve to underscore the importance of thinning. Thinning which promotes diameter growth also promotes heartwood growth, increasing both productivity and quality of the trees.

Table 4. Heartwood and sapwood width, by treatment, following thinning in 40-year-old redcedar stands. Standard deviations are given in parenthesis. Significance level is indicated.

Location	Treatment	Heartwood (20 years)	Sapwood (20 years)	Heartwood (40 years)	Sapwood (40 years)
South	Unthinned	2.38 (0.63)	0.90 (0.29)	2.65 (0.93)	0.80 (0.36)
	Thinned	2.42 (0.77)	0.90 (0.26)	3.10 (0.91)	0.88 (0.27)
	P value	0.80	0.98	0.04	0.32
North	Unthinned	3.12 (0.92)	0.97 (0.32)	-	-
	Thinned	3.86 (0.77)	1.15 (0.14)	-	-
	P value	0.02	0.04		

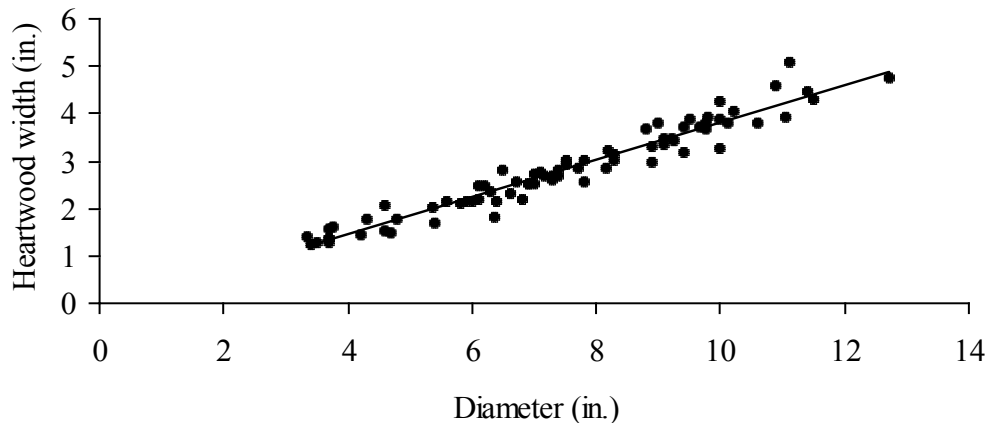


Figure 1. Eastern redcedar heartwood width as a function of tree diameter 40 years after thinning.

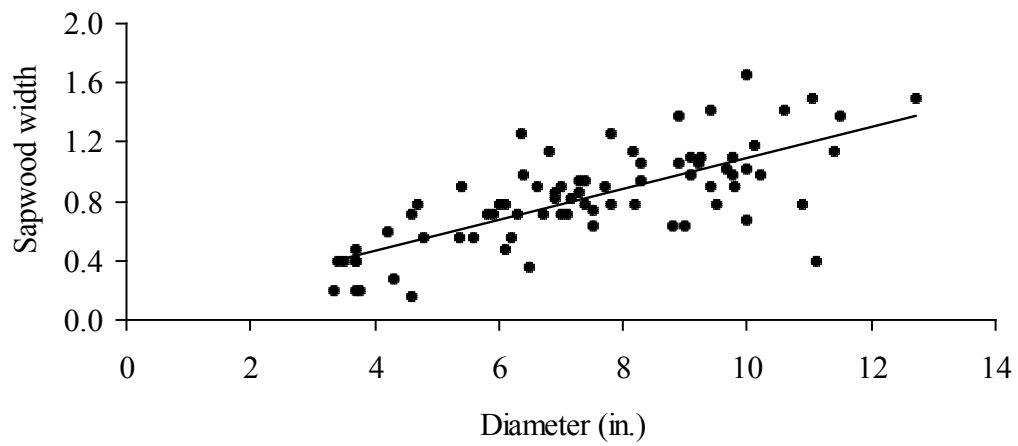


Figure 2. *Eastern redcedar sapwood width as a function of tree diameter 40 years after thinning.*



Eastern redcedar disk from thinned stand showing proportion of heartwood.

▲ ▲ ▲ ▲ ▲ ▲ ▲ CONCLUSION ▲ ▲ ▲ ▲ ▲ ▲ ▲

Good news for resource managers and private landowners who may wish to actively manage eastern redcedar stands is that thinning improved mean individual-tree diameter growth, and basal area growth rate, improved the health of the stand by reducing stand mortality, and above all it improved the economic value of the trees by

increasing the heartwood formation. We believe that if the stands were thinned at a younger age, better growth and heartwood formation would have been obtained than reported here. Our results show that potential exists for managing naturally regenerated stands to promote yield and value of timber through thinning.

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